

Improving EFL Students' Learning Achievements and Behaviors using a Learning Analytics-based e-book System

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Abstract: An e-book system allows students to access learning materials regardless of location or time. However, reading e-books without additional guidance could be inefficient for students and thereby affecting their learning engagement and learning outcomes. In this study, a learning analytics-based (LA) e-learning approach was proposed to resolve the situation. Moreover, experimental design methods were used to explore the relationship between the learning engagement, behavior, and achievement of students who learned with the LA e-learning approach. The research results show that the learning performance of high- engagement participants using the LA e-learning approach is better than that of low- engagement participants. In addition, the findings indicated that the proposed method could support low and medium learners to improve their learning achievement. These findings could be a valuable reference for those who intend to develop an effective learning analytics-based learning approach through e-book systems.

Keywords: E-book, e-learning, learning behavior, learning engagement, learning analytics

1. Introduction

Conventionally, English as a Foreign Language (EFL) learners passively receive the instruction given by teachers in the class without interaction, so they have little chance to engage in reading by themselves (Sanprasert, 2010). In addition, EFL learners generally rely on their teacher's translation of the texts (Mollaei, Taghinezhad, & Sadighi, 2017); therefore, they tend to become disengaged from learning (Larsen-Freeman, 2000). Besides, high school English courses in many countries are mainly lecture-based and involve a large number of students. This arrangement hinders students from engaging with English classes, as instructors cannot monitor the students' learning when the class is big.

When considering the use of technologies, it is important to think about whether they facilitate students' engagement. Language learning with digital technologies offers EFL learners more chances to improve their engagement and can lead them to become autonomous learners (Yang, 2012; Zulkepli et al., 2018). Particularly, e-books have been shown to have a positive impact on enhancing literacy skills (Shamir, Segal-Drori, & Goren, 2018). Researchers have studied ebook systems and indicated that they could facilitate learners' interaction with the learning content, such as when using an interactive e-book-based flipped learning approach (Hwang et al., 2017) to enhance both in-class and out-of-class learning. Their study showed that the learners had more chances to engage not only in class but also after class. In addition, previous studies have also suggested that learning logs from the learning system can assist students and teachers (Hwang et al., 2017). In addition, Hsieh and Huang (2019) claimed that while students benefit from the ebook features such as color markers and annotation, students' learning

behaviors while using books have not been evaluated extensively. Little attention has been paid to visualizing and analyzing the relationship between learners' strategies and their learning outcomes in the learning logs. Besides, few studies have looked specifically at learners' engagement levels concerning ebook learning. Therefore, it is necessary to explore this aspect of learning analytics. This study investigated students' engagement levels with the proposed learning analytics-based approach and their relationship with the students' learning achievement and behaviors.

Therefore, in this study, a learning analytics-based (LA) e-learning approach was proposed to empower students to have more autonomous learning during the ebook reading process. An experiment was conducted with first-grade senior high school students in Japan. This study aimed to investigate the participants' learning achievement, engagement, and learning behaviors. The following research questions guided the study:

RQ1. What are the impacts of the LA e-learning approach in terms of learning achievements of the high-engagement group and the low-engagement group using the LA e-learning approach?

RQ2. What are the impacts of the LA e-learning approach in terms of learning achievements of the low achievers using the LA e-learning approach?

RQ3. Is there any correlation between their learning behaviors and learning achievement?

2. Literature review

2.1 Learning engagement

Learning engagement has been defined as consisting of endeavors to learn (Strati, Schmidt, & Maier, 2017). Also, Han and Hyland (2015) stated that engagement means using recognizable strategies to support students' learning outcomes. Chen, Hwang, and Chang (2019) claimed the significance of highlighting student involvement in autonomous learning engagement in learning systems. For example, Chen, Lu, and Lian (2019) compared learners' engagement when playing a game, watching a video, and in the classroom. Previous studies relied on eye trackers (Kao, Chiang, & Foulsham, 2019), questionnaires (Abubaker & Lu, 2017), or coding (Abdelhalim, 2017; Li, Ma, Wang, Lan, & Dai, 2019) to evaluate students' engagement. For example, Li and his colleagues (2019) studied pre-school children's engagement by videotaping then coding their behavioral patterns and performances.

Other studies have found that engagement with the textbook was related to student learning achievement (Junco & Clem, 2015; Kuh, 2009), and the time and effort students devote to activities that are empirically linked to desired outcomes. Specifically, they identified that time spent reading tends to be one of the critical variables to predict students' academic outcomes. Therefore, engagement in this study was explored in terms of the time students invested in their learning using the ebook system to achieve the expected learning outcomes. Their learning log data were generated from the ebook system to represent their learning engagement.

2.2 Learning approach and e-books in English language learning

The SQ3R reading approach is a famous reading comprehension method developed by Robinson (1946). It focuses on learners' knowledge and comprehension, which are categorized as lower-level thinking items. The purposes of these six steps are to keep students engaged in reading when using the ebook system. The first two, scanning and skimming, can support learners in developing their reading comprehension (Anderson, Rourke, Garrison, & Archer, 2001), and facilitate their reconstruction of the text structure. Scanning requires readers to read rapidly to locate details-specific information (Brantmeier, 2002; Liaw, 2017) to get answers from the questions in the assignment or exam, while skimming is reading quickly to get a general overview of the paragraph. Question posing involves comprehending, constructing knowledge, and thinking about the questions during the learning process (Sung, Hwang, & Chang, 2016). Replying to the question helps promote students' deep comprehension of the reading content, and enables them to think, address, and solve questions (Ye, Chang, & Lai, 2019). Learning engagement provides learners with a structured opportunity to scrutinize their learning (Verpoorten, Westera, & Specht, 2012).

3. Method

In this study, the impacts of learning analytics-based (LA) e-learning approach on students' learning achievement, learning engagement, and learning behaviors were investigated. An experiment was conducted to capitalize on the quantitative method.

3.1 LA e-learning approach

In this study, an e-book reader, BookRoll, (Flanagan & Ogata, 2018), was adopted. The e-book reader provides features such as functions of the marker, quiz, and memo. Robinson's SQ3R was tailored as the LA e-learning approach and integrated into the e-book reader. In this study, question reply and reflection were added to the learning approach because they are categorized as higher-level thinking items (Pena-Shaff & Altman, 2015). Therefore, the revised learning strategies of Scanning Skimming, Question, Read, Reply, and Reflection were developed as the learning analytics-based (LA) e-learning approach for this study. The learners can use the proposed approach (i.e., Scan & Skim, Read, Reply, and Reflect) procedure to go through the learning in the e-learning system step by step, shown in Figure 1. This means that the participants first scanned for the main ideas and used the red marker function to highlight important ideas. At the same time, they skimmed for the general ideas, and they used the yellow marker function if they did not understand the gist of the paragraph. In the quiz function, they could read the questions that the teacher had prepared, and they read the text to find the answer and then reply to the question. The memo feature was to indicate sections where students could make their annotations at the page level. The last step of the LA e-learning approach was to use the memo function to record their reflection of what they had learned.

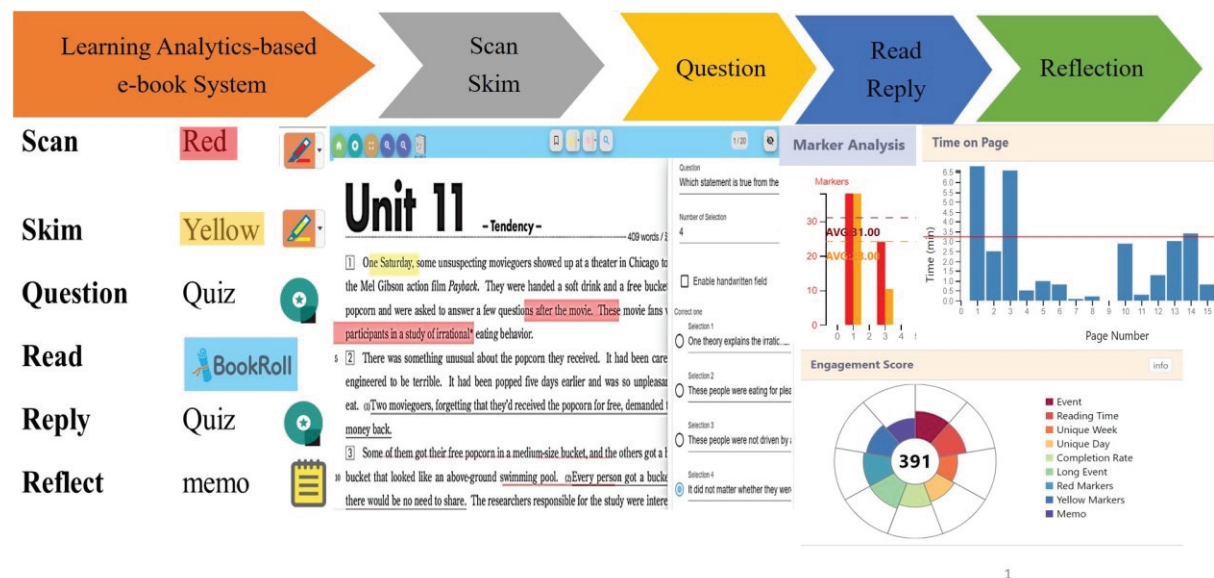


Figure 1. LA e-learning procedure.

In addition, teachers can set questions in the Quiz function. Students were required to answer the questions in the quiz function after scanning and skimming. When they had done the scanning and skimming and had replied to the question, they should then write their reflection of the reading in the memo function. In the LA-learning system, the analysis tool displays the learning logs from the e-book reader, including the red markers for scanning, the yellow markers for skimming in the Marker list panel, and the quiz function for the question reply scores in Quiz Score panel, and the memo reflection in the memo panel. The learning analytics-based (LA) e-learning activities were recorded by the analysis tool as students' learning log data, as shown in Figure 2.

Analysis Tool

Data exchange

Class Setting

Graph Setting

English

Log out

Marker List panel

クミコ	"Things like that don't trick me" or "I'm pretty good at knowing"
ショウト	"Things like that don't trick me" or "I'm pretty good at knowing"
ショウマ	"Things like that don't trick me" or "I'm pretty good at knowing"
ナナミ	"We've run other popcorn studies, and (5)the results were always the

Memo List panel

Export

What do you think about the result? I was surprised it because I do not think quantity is not important.

[1] What do you prefer? Eating with a bigger container or a smaller container? Why? I prefer eating with a bigger because if you eat a lot of food, the person who made it feel happy.

Quiz Score panel

Number of Students

First Attempt

Questions		
Who were these movie fans?	36	77.8
Why did everyone get one bucket, some of them get free popcorn in a medium-siz...	33	78.8
What sizes of popcorn did the participants receive?(3)	32	90.6
Who is the researcher of the study?(6)	29	65.5
What is the result of the popcorn study?(5)	29	89.7
Which statement is true from the paragraph 7.	27	40.7
What did the participants think about this result of the study? (8)	25	72.0

Figure 2. The LA and Analysis Tool interface.

3.2 Participants

This study used an experimental design combined with a quantitative method. One of the Integrated English Competency (IEC) classes of students were recruited from the first-grade high school in the west-central Honshu Island, Japan. The IEC course aims to assist students in vocabulary acquisition, grammar use, and reading comprehension skill development. The participants (n=40, 17 males, 23 females) adopted the LA e-learning approach, and their ages ranged from 15 to 16. At the time of the research, they had been studying English for approximately four years. Their English proficiency level is roughly equal to a pre-intermediate to intermediate level or a B1 in the CEFR scale. Their English classes comprised two 50-minute lessons a week throughout the academic year. One specific textbook-NEO See-the Modern Approach (Watanabe, 2016) was assigned and approved for the IEC course. The textbook is a collection of Basic English readings selected from the themes that frequently appeared in recent university entrance examinations in Japan.

3.3 Experiment procedure

An experiment was conducted on the Integrated English Competency (IEC) course in the fall 2019 term to evaluate the proposed learning approach on the learning achievement, and learning behavior of the students learning. The participants in the LA e-learning approach were instructed to appropriately operate the tablet and the e-learning system to learn the content. The teacher started a unit by encouraging the students with warm-up activities. Keywords were presented and reinforced through sentence-building exercises, explanations, and exercises on grammar rules. The purposes of the teacher's instruction were to activate students' background knowledge by asking general to specific questions through modeling, guiding the students to help them become familiar with the vocabulary, and monitoring their comprehension by asking questions from the textbook.

The experiment was conducted on the two units of an Integrated English Competency course, which aims to enhance the high school students' English reading skills. Before the experiment, the participants spent one week on the pre-test to evaluate their prior knowledge of English reading. Following that, the participants were required to learn and use the LA e-learning approach in the e-book reader for four weeks. After four weeks of the learning proposed approach, the participants took the post-test regarding the unit content they had learned during these four weeks. In this study, students were learning Units 11 and 12.

3.4 Data analysis

One English pre-test and post-test were created, and the test validity was ensured by the high school teachers from the high school and the researchers. The pre- and post-test as the learning achievement tests in this study consisted of three sections focusing on receptive English reading skills. The pre-test measured the participants' English language proficiency, and the post-test was to monitor the students' learning achievement for the two learning units. The questions were from Units 11 and 12 in the textbook, and the test comprised 27 multiple-choice questions. There were three sections for learning

achievement, including lexical, semantic, and reading comprehension questions, with a total score of 100. The Cronbach's alpha value of the achievement test is .97.

To examine the effect of the LA e-learning approach on English learning achievement to analyze the transition patterns of the students' achievements across the pre- and post-test, the interactive Stratified Attribute Tracking (iSAT) method was used (Majumdar & Iyer, 2016). iSAT can visualize the distribution of the pre-test and post-test scores of the cohort of learners and track the changes in the overall learning results. The scores of both the pre- and post-test were stratified based on the top 25% (10 participants) as high proficiency, the middle 50% (10 participants) as medium proficiency, and the bottom 25% (10 participants) as low proficiency (Papi & Abdollahzadeh, 2012).

Learning behaviors include annotations using the red marker, yellow marker, memo, and attempting quiz functions of the e-book reader. Such learning behaviors were automatically logged within the system. The counts of the specific learning behaviors were accessible to both the researchers and teachers through the learning dashboard called Analysis Tool. The participants' learning behaviors were extracted from the number of times the red marker highlight was used for scanning, the number of times the yellow marker was used for skimming, the quiz scores as replying to questions, and the number of times memos were made as to their reflection of the reading. The participants' time spent learning the unit was analyzed as to their learning engagement. Thus, the participants' levels of engagement and learning behaviors were collected directly from the learning logs of the e-learning system during the 4 weeks of study. Then the relationships between the learning achievement, engagement, and behaviors were computed using the statistical analysis system, SPSS.

Besides, the differences between the high- and low-engagement EFL learners learning the two units of the two-class sections were analyzed. The participants were ordered from the highest to the lowest engagement groups based on their level of engaged behavior obtained through the e-learning system. The learning logs in the e-learning system of participants' time spent learning the materials were analyzed as to their learning engagement. Engagement groups were based on the total time spent learning, as recorded in the learning logs obtained through the e-learning system. The grouping was calculated as the top 25% (10 participants), the middle 50% (20 participants), and the bottom 25% (10 participants) groups accordingly (Papi & Abdollahzadeh, 2012), and the cohorts were labeled as the high-engagement, moderate- engagement, and low-engagement groups. According to the ANOVA results for the specified groups, it did truly represent the different engagement groups ($F = 90.33$, $p < .05$, $\eta^2 = 0.17$). The results of the analysis strongly confirmed a significant difference in the two units' average time (in minutes) of the high-engagement group ($M = 51.60$, $SD = 4.72$), the moderate-engagement group ($M = 35.28$, $SD = 5.43$), and the low-engagement group ($M = 22.55$, $SD = 3.49$), as displayed in Table 1. Furthermore, post hoc analysis was performed to examine specific differences in the engagement of the three groups.

Table 1. ANOVA result of the learning time of the three levels of engagement

Level of Engagement	N	M(min)	S.D.	F	Post hoc tests
High-engagement (a)	10	51.60	4.72	90.33*	a > b
Moderate-engagement (b)	20	35.28	5.43		b > c
Low-engagement (c)	10	22.55	3.49		

Note. * $p < .05$

4. Results

4.1 Analysis of English learning achievement

In order to answer the first research question concerning the differences between high-engagement and low-engagement EFL learners in terms of the effect of the LA e-learning approach on English learning achievement, the participants were ordered from the highest to the lowest engagement groups based on their level of engaged behavior obtained through the e-book reader. The top one fourth (10 participants), the one half (20 participants), and the bottom one fourth (10 participants) groups were

distinguished and labeled the high-engagement, moderate- engagement, and low-engagement groups, respectively.

The ANOVA outcome of the comparison of the three levels of engagement for the LA e-learning approach is shown in Table 2. The result indicated that there was a significant difference in the mean scores of the learning achievement test for the high-engagement group ($M = 90.70$, $SD = 2.50$) and the low-engagement group ($M = 65.10$, $SD = 6.88$), $F = 39.58$, $p < .001$), as presented in Table 3. In other words, high-engagement in the LA e-learning approach can successfully promote students' learning achievements.

Table 2. ANOVA result of the learning achievement of the three levels of engagement

Learning achievement	N	M	S.D.	F	Post hoc tests
High-engagement (a)	10	90.70	2.50	39.58**	a > b
Moderate-engagement (b)	20	75.95	8.91		b > c
Low-engagement (c)	10	65.10	6.88		a > c

Note. * $p < .001$

Further, iSAT analysis highlighted how a group of similar achievers in the pre-test performed in the post-test. Figure 3 provides the overall transition pattern among different levels of learners. There were 7 participants (17.5% of total) who improved from the low in the pre-test to the medium in the post-test. There were 6 participants (15% of total) who improved from the medium in the pre-test to the high cohorts, respectively, in the post-test.

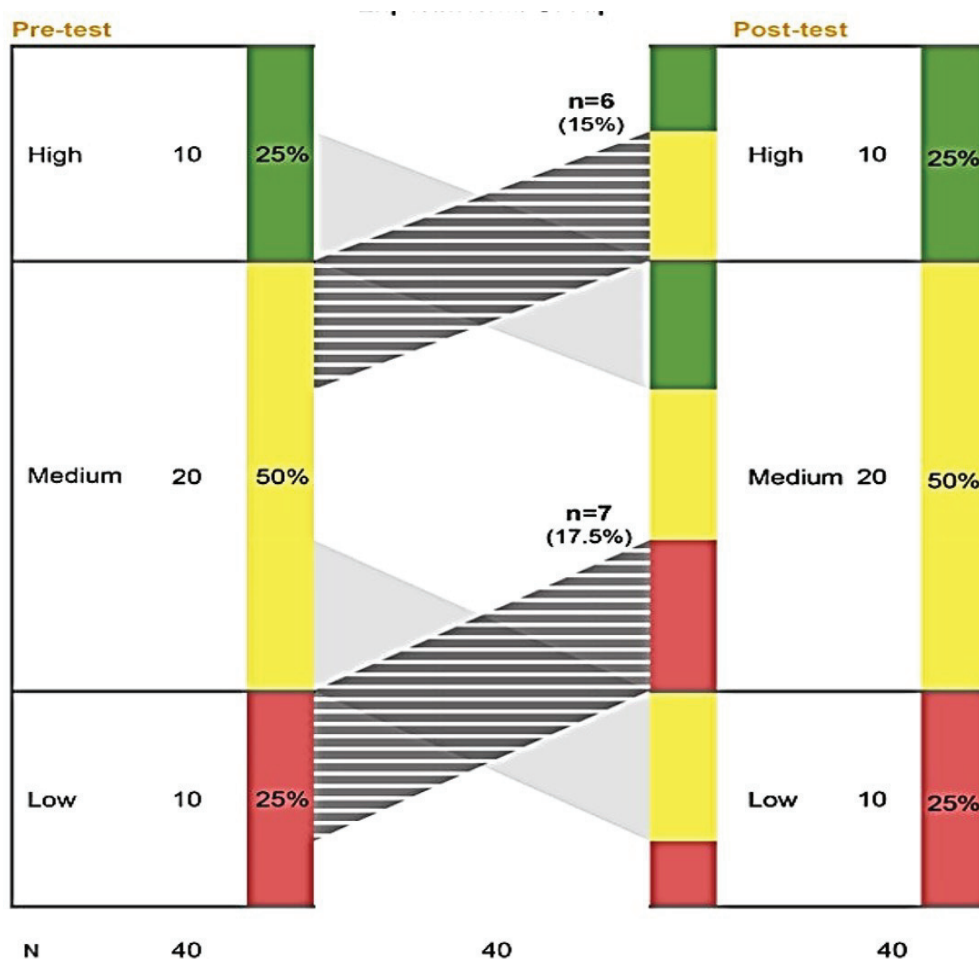


Figure 3. Stratified Attribute Tracking diagram for the analysis of different levels of learning achievers.

The overall distribution data of learning time, learning achievement, and learning engagement to view the general trends in Figure 4.

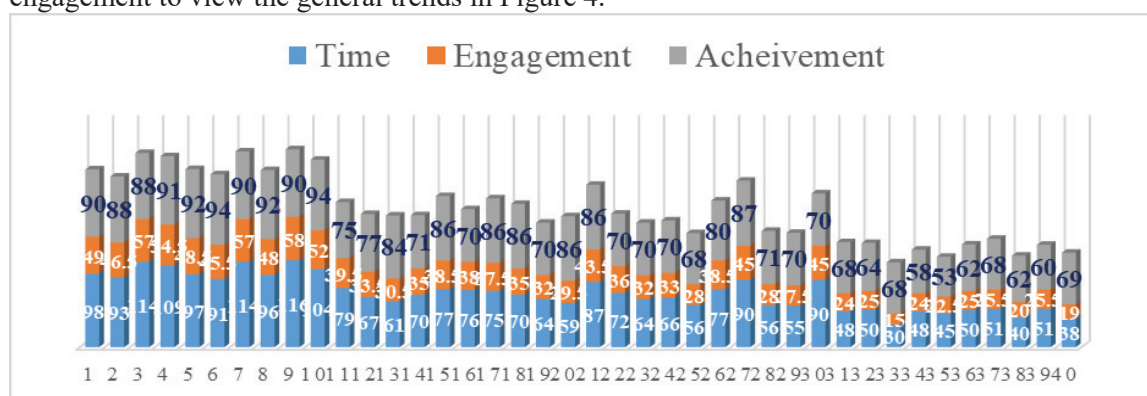


Figure4. The distribution data of learning time, learning achievement, and learning engagement.

4.2 Analysis of learning engagement of the LA e-learning

In this study, a correlational analysis not only concerning reading time and performance but also with the number of events (learning behavior) and performances. Table 3 shows the correlations between learning behaviors and learning achievement. Learning achievement was significantly correlated with reflection; reflection was significantly correlated with question replying and reading; reading was significantly correlated with scanning and question replying; question replying was significantly correlated with scanning, and skimming was significantly correlated with scanning.

Table 3. Correlations between the learning behaviors and learning achievement

	Scan	Skim	Question Reply	Reading	Reflection	Achievement
Scan	1					
Skim	.519**	1				
Question Reply	.318*	.141	1			
Reading	.309*	.212	.908**	1		
Reflection	.242	.275	.589**	.615**	1	
Achievement	.057	.089	.195	.179	.328*	1

Note. * $p < .05$, ** $p < .01$.

5. Discussion and conclusions

In this study, the LA e-learning approach was developed, and the experiment was employed to explore the learning impact of the LA e-learning approach in a first grade English class at a senior high school in Japan. The effects of different levels of engagements were first investigated. Not only a correlational analysis for reading time and performance but also with the number of events (learning behavior) and performance were conducted. The iSAT analysis specified that more participants improved from low to medium and medium to high in the post-test. This indicates that the LA e-learning approach can guide low and medium learners to increase their learning achievements. These results suggest that the LA e-learning approach does help with learning achievement gain. The LA e-learning approach was most effective in terms of improving learners' achievements, depending on the participants' levels of proficiency. Consequently, it is necessary to integrate some learning strategies to optimize the use of technology in e-learning. Hsieh and Huang (2019) suggested that learning approaches should be cautiously designed and pedagogically applied to suit learners' proficiency levels.

Furthermore, the experimental results showed that the high-engagement group had higher scores on the learning behaviors than the low-engagement group. Bonafini, Chae, Park, and Jablow's (2017) study also found that students' engagement in the discussion board and video lecture increased the possibility of learning achievement. Moreover, Jamaludin and Osman (2014) indicated that learning engagement could support active learning and increase learning outcomes. Additionally, an analysis showed that significant correlations existed between learning behaviors and learning achievement. Consequently, it

is concluded that employing the LA e-learning approach, and students' learning behaviors were directly related.

However, there are several limitations to the present study that should be noted. First, the e-learning system was designed to provide learning materials and collect the learning logs, so the learners' autonomous learning is essential in using the system. The total time spent on learning in the research only includes the time using the system, so learners' learning time without using the system was not able to assess. Second, the experiment lasted merely four weeks. The participants might not have practiced the learning analytics-based technique for long enough to acquire the strategies. Third, the proposed approach was only applied to a high school course; the findings might not be able to represent the effectiveness of the same approach for a longer period and different education levels. The current study focused only upon a class of high school students using an e-learning system in a single English course. In addition, a limited type of engagement was evaluated and discussed; other types of engagement, such as psychosocial processes involving students' cognitive and affective dimensions and organizational culture (Kahu, 2013) were not addressed in this study. Accordingly, the researchers of this study intend to expand their future research by adding different types of engagement in the experimental study.

To sum up, the LA e-learning approach was integrated into an e-learning system to allow students to engage in autonomous learning as well as to have positive learning behaviors in the system. For future research, it would be valuable to explore the effectiveness of with or without the LA e-learning approach in higher education of language learning courses. It would also be worth measuring the impacts of the approach from various aspects, such as students' higher-order thinking, self-efficacy, and self-directed learning. In addition, the investigation of students' cooperative behaviors, as well as their interactive behaviors before class, in class, and out of class, could be valuable. Further research can also probe how to use different learning content to promote low-engagement students' involvement in improving their learning. Finally, further investigations into e-learning systems in listening speaking or writing classrooms can provide diverse pedagogies of English language teaching development.

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